

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



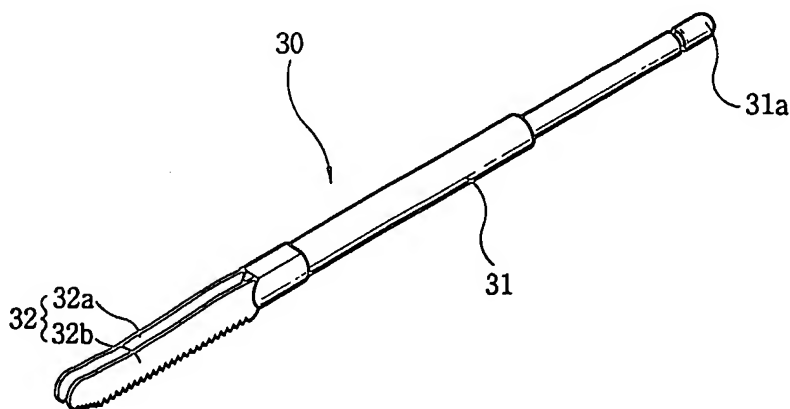
(43) International Publication Date  
10 May 2002 (10.05.2002)

PCT

(10) International Publication Number  
WO 02/36023 A1

- (51) International Patent Classification<sup>7</sup>: A61B 17/16
- (21) International Application Number: PCT/KR01/01504
- (22) International Filing Date:  
6 September 2001 (06.09.2001)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
2000/64021 30 October 2000 (30.10.2000) KR
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- (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:  
— with international search report
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- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SURGICAL SAW FOR CUTTING OFF CHEEK BONES



(57) Abstract: The surgical saw according to the present invention comprises an arm fixed by mounting the rear end portion thereof in a jaw of a handle; and a double saw blade part connected with the front end portion of the arm and having two saw blades arranged side by side in a certain distance. In case that the surgical saw is used in surgeries for cutting off cheek bones, the surgical saw can precisely cut off portions of the cheek bones in a width set in advance by precisely cutting off two positions of the cheek bones in a precise cutting-off length at

the same time so that the portions of cheek bones can be conveniently cut off, the periods of time for surgeries can be reduced, and an occurrence frequency of surgery aftereffects due to different cutting-off widths for the left and right cheek bones can be reduced.



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## **SURGICAL SAW FOR CUTTING OFF CHEEK BONES**

### **TECHNICAL FIELD**

The present invention relates to a surgical saw for cutting off cheek  
5 bones which is used for cutting off portions of cheek bones during plastic  
surgeries for smoothing bulged cheek bones, and more particularly to a  
surgical saw for cutting off cheek bones which has spacing-adjustable  
double saw blades capable of precisely cutting off cheek bones at one  
time in a predetermined width.

10

### **BACKGROUND ART**

The cheek bones such as the zygomatic buttresses, are bones  
bulged out below the tails of the eyes on the both sides of a face.  
Appropriate cheek bone bulges give a vigorous and good look and a  
15 three-dimensional effect, but excessive cheek bone bulges cause a face  
to look wide and a nose to look relatively low in front view so that the  
bulges may be a factor for a face appearance to be deteriorated.  
Particularly, the excessive bulges together with a square chin which is  
distinctly protruded and angled cause a strong and rough appearance so  
20 that they give an adverse feeling to others.

Accordingly, plastic surgeries are being widely carried out to look  
mild in appearance by smoothing bulged cheek bones in recent.

Methods and difficulty degrees of plastic surgeries for smoothing  
cheek bones are dependent upon bulged directions and degrees of the  
25 cheek bones. In case that cheek bones are protruded forwards, it is  
enough for their smoothing only to trim off protruded portions of the cheek  
bones, but in case that cheek bones are severely protruded forwards or  
cheek bones are protruded sideways, an effect can be brought only when

portions of the cheek bones are cut off, and remaining separate portions on both sides are pushed toward each other in order for both cross-sectioned ends of the remaining cheek bones to be joined to each other.

In the meantime, a conventional surgical saw 10 for cutting off  
5 cheek bones which is used for removing portions of the cheek bones in cheek bone plastic surgeries has an arm 11 formed in an elongate straight bar shape and a saw portion 12 mounted on the front portion of the arm 11 as shown in FIG. 1, and a fixture portion 11a on the rear side of the arm 11 is mounted in a jaw 21 of a handle 20 in which an electric  
10 motor is built, so that the jaw 21 reciprocates the saw to cut off portions of cheek bones 101 of a skull 100 exposed through skin opened by the saw portion 12 as shown in FIG. 2.

However, in case that the conventional surgical saw for cutting off  
cheek bones as mentioned above is used, the saw portion 12 has only  
15 one saw blade so that at least two times cutting operations are needed to partially cut off cheek bones, as shown in FIG. 3, causing a problem that surgeries become very cumbersome as well as require lots of time. Further, a cutting interval has to be adjusted based on naked eyes through the skin opened by cutting, so that it is very difficult to adjust  
20 cutting-off widths of both individual cheek bones of a face due to a difficult securing of a visual field, causing a high occurrence frequency of surgery aftereffects bringing an asymmetry of the left and right sides of a face.

### DISCLOSURE OF INVENTION

25 Accordingly, in order to solve the above problems caused by the conventional surgical saw for cutting off cheek bones, it is an object of the present invention to provide a surgical saw for cutting off cheek bones which has two saw blades a distance between which can be adjusted and

fixed beforehand to precisely cut off portions of the cheek bones in a predetermined width with a one-time cutting operation.

In order to achieve the above object, the surgical saw for cutting off cheek bones according to the present invention comprises an arm  
5 fixed by mounting the rear end portion thereof in a jaw of a handle; and a double saw blade part connected with the front end portion of the arm and having two saw blades arranged side by side in a certain distance.

In the above structure, the individual saw blades of the double saw blade part are preferably fixed on both sides of the front end portion of the  
10 arm by a fixing means in a distance to each other.

Further included are at least one or more spacing members selectively placed between the individual saw blades of the double saw blade part and the sides of the front end portion of the arm on which the individual saw blades are closely fixed, and for enabling the distance of  
15 the individual saw blades to be adjusted.

Further, the left and right sides of the spacing members and the both sides of the front end portion of the arm, which are closely contacted with each other, have up-and-down movement preventing structures for preventing the individual saw blades from relative rotations with respect to  
20 the arm by restraining relative movements in up-and-down directions with respect to each other and movements in up and down directions of the individual saw blades.

Furthermore, the fixing unit includes a bolt transversely penetrating the individual saw blades and the front end portion of the arm and a nut  
25 engaged with the bolt.

### BRIEF DESCRIPTION OF THE DRAWINGS

The above object and other advantages of the present invention

will become more apparent by describing in detail a preferred embodiment thereof with reference to the attached drawings, in which:

FIG. 1 is a perspective view for showing a conventional surgical saw for cutting off cheek bones;

5        FIG. 2 is a perspective view for showing a motor-driven surgical saw to which a conventional saw for cutting off cheek bones is mounted;

FIG. 3 is a view for showing a conventional surgical saw for cutting off cheek bones in use;

10       FIG. 4 is a perspective view for showing a surgical saw for cutting off cheek bones according to an embodiment of the present invention;

FIG. 5 is a perspective view for showing a motor-driven surgical saw to which a surgical saw for cutting off cheek bones is mounted according to an embodiment of the present invention;

15       FIG. 6 is a view for showing a surgical saw for cutting off cheek bones in use according to an embodiment of the present invention;

FIG. 7 is an exploded perspective view for a surgical saw for cutting off cheek bones according to another embodiment of the present invention; and

20       FIG. 8 is a cross-sectioned view taken along line VIII-VIII of FIG. 7.

#### BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, the structure and operations of a surgical saw for cutting off cheek bones will be described in detail through preferred embodiments of the present invention.

25       FIG. 4 is a perspective view for a surgical saw for cutting off cheek bones according to an embodiment of the present invention, and FIG. 5 is a perspective view for a motor-driven surgical saw to which a surgical saw for cutting off cheek bones is mounted according to an embodiment

of the present invention.

As shown in FIG. 4, a surgical saw 30 for cutting off cheek bones according to an embodiment of the present invention has an arm 31 of an elongate bar shape and a double saw blade part 32 mounted on the front  
5 end of the arm 31.

The arm 31 is a round bar of a certain length on the front end of which the double saw blade part 32 is mounted and on the rear end of which a fixture portion 31a having a connection structure is formed to be connected with a jaw 21 of a handle 20, as shown in FIG. 5, so that the  
10 double saw blade part 32 is fixed to the handle 20 with a certain distance from the front end of the handle 20 to be easily controlled as well as to transfer a linear reciprocation kinetic energy of the handle 20 to the double saw blade part 32. Particularly, in case that the handle has a motor(not shown) therein as in the present embodiment, a linear  
15 reciprocation kinetic energy of the jaw 21 structured to be reciprocated by the motor is transferred to the double saw blade part 32.

The double saw blade part 32 are connected to the front end of the arm 31 to be linearly reciprocated together with the arm 31 so that the double saw blade part 32 directly cut off portions of cheek bones with  
20 plural saw teeth formed along the lower sides of the blade part 32. The double saw blade part 32 is constructed with two saw blades 32a and 32b arranged side by side in a certain interval and simultaneously cuts off at least two portions of cheek bones.

With the above structure, in the surgical saw 30 for cutting off  
25 cheek bones according to an embodiment of the present invention, the arm 31 and double saw blade part 32 are linearly reciprocated by the jaw 21 which is linearly reciprocated by the motor built in the handle 20, and, in case that the surgical saw 30 is used in surgeries for cutting off

portions of cheek bones as shown in FIG. 6, the surgical saw 30 can saw at least two positions of cheek bones 101 at the same time so that the saw 30 can cut off a portion of the cheek bones 101 with only a one-time cutting operation.

5           Meanwhile, FIG. 7 is an exploded perspective view for showing a surgical saw for cutting off cheek bones according to another embodiment of the present invention.

As shown in FIG. 7, a surgical saw 40 for cutting off cheek bones according to another embodiment of the present invention includes a  
10   structure that individual separated saw blades of a double saw blade part 42 are fixed to the front end portion of an arm 41 by a fixing unit constructed with a bolt 43 and a nut 44. In particular, plural spacing members 45, for example, zero to four spacing members, can be selectively placed on both sides of the front end portion of the arm 41 and  
15   between individual saw blades 42a and 42b, and the members 45 and the blades 42a and 42b are tightly fixed to the arm 41 by the bolt and nut 43 and 44. Further, as shown in FIGs. 7 and 8, structures for preventing up-and-down movements are formed on the left and right sides of each of spacing members 45 as well as of the front end portion of the arm 31,  
20   having convex and concave portions to be matched with each other to restrain the individual saw blades 42a and 42b from relative movements in up and down directions among the constituents of the structure as well as movements of the individual saw blades 42a and 42b in up and down directions after the individual saw blades 42a and 42b are fixed to the  
25   front end portion of the arm with the spacing members 45 placed between the blades 42a and 42b and the front end portion.

With the structure mentioned above, in case that the surgical saw 40 for cutting off cheek bones according to another embodiment of the

present invention is used in surgeries for cutting off cheek bones 101, the two saw blades 42a and 42b of the double saw blade part 42 can saw two positions of the cheek bones 101 at the same time so that a portion of the cheek bones 101 can be cut off through a one-time cutting operation. In particular, since the distance between the two saw blades 42a and 42b of the double saw blade part 42 can be adjusted by adding the spacing members 45, the surgical saw 40 has an advantage in that widths of cheek bones to be cut off can be diversely adjusted.

The surgical saws for cutting off cheek bones according to the present invention as stated above in detail carry out linear reciprocation movements by the handle or the motor built in the handle. In case that the saws are used in surgeries for cutting off cheek bones, the interval between the saw blades can be adjusted in advance and both saw blades of the combined double saw blades can cut two positions of the cheek bones at the same time in a precise cutting-off length so that the surgical saws can precisely cut off a portion of the cheek bones by a predetermined cutting-off width with a one-time cutting operation. Accordingly, when the surgical saws for cutting off cheek bones according to the present invention are used for surgeries for cutting off cheek bones, the surgeries for cutting off portions of cheek bones can be very conveniently carried out as well as the periods of time for the plastic surgeries for cheek bones can be greatly reduced. In addition, since portions of both cheek bones can be precisely cut off by a width set in advance, an occurrence frequency of asymmetric aftereffects of the left and right sides of a face due to different cutting-off widths of the left and right cheek bones upon plastic surgeries of the cheek bones can be drastically reduced.



## CLAIMS

What is claimed is:

1. A surgical saw for cutting off cheek bones, comprising:  
an arm fixed by mounting the rear end portion thereof in a jaw of a  
5 handle; and  
a double saw blade part connected with the front end portion of the  
arm and having two saw blades arranged side by side in a certain  
distance.
2. The surgical saw as claimed in claim 1, wherein the individual  
10 saw blades of the double saw blade part are fixed on both sides of the  
front end portion of the arm by a fixing means in a distance to each other.
3. The surgical saw as claimed in claim 2, further comprising at  
least one or more spacing members selectively placed between the  
individual saw blades and the sides of the front end portion of the arm on  
15 which the individual saw blades are closely fixed, and for enabling the  
distance of the individual saw blades to be adjusted.
4. The surgical saw as claimed in claim 3, wherein the left and  
right sides of the spacing members and the both sides of the front end  
portion of the arm, which are closely contacted with each other, have up-  
20 and-down movement preventing structures for preventing the individual  
saw blades from relative rotations with respect to the arm by restraining  
relative movements in up-and-down directions with respect to each other  
and movements in up and down directions of the individual saw blades.
5. The surgical saw as claimed in any of the claims 2 to 4, wherein  
25 the fixing means includes a bolt transversely penetrating the individual  
saw blades and the front end portion of the arm and a nut engaged with  
the bolt.

1/5  
Fig.1

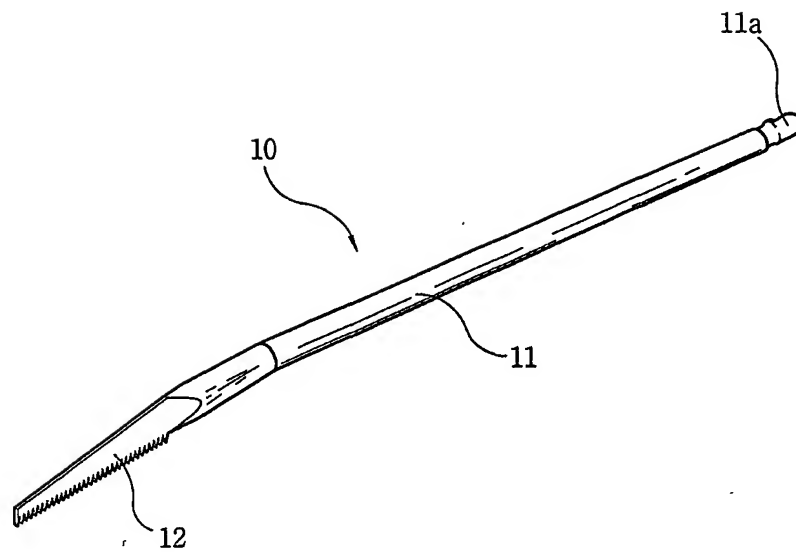
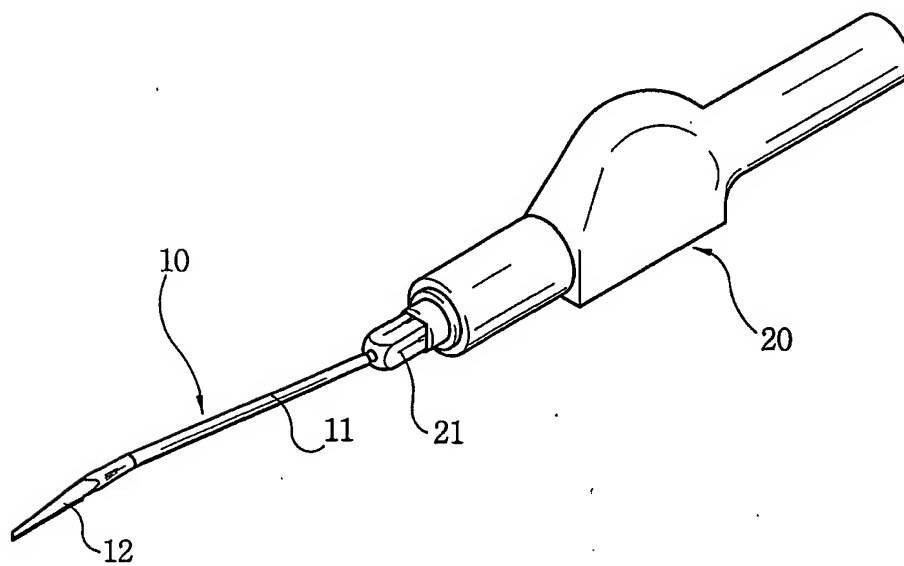
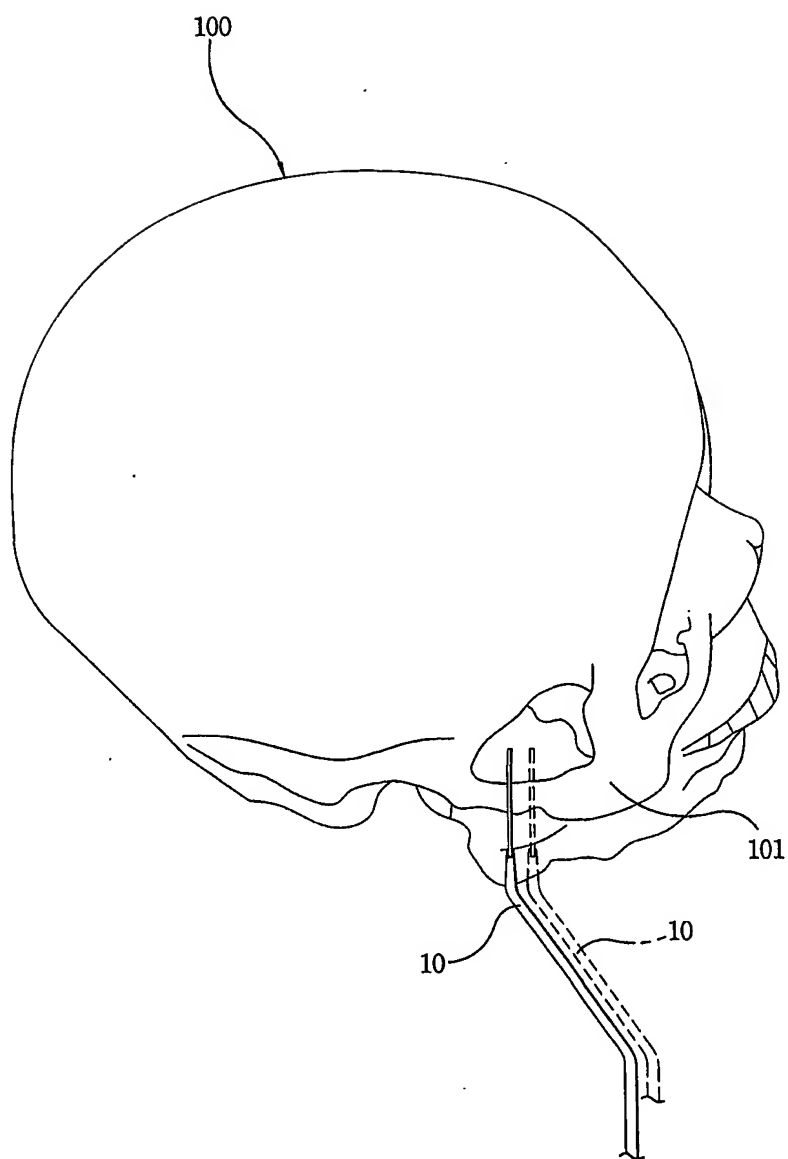


Fig.2



2/5  
Fig.3



3/5  
Fig.4

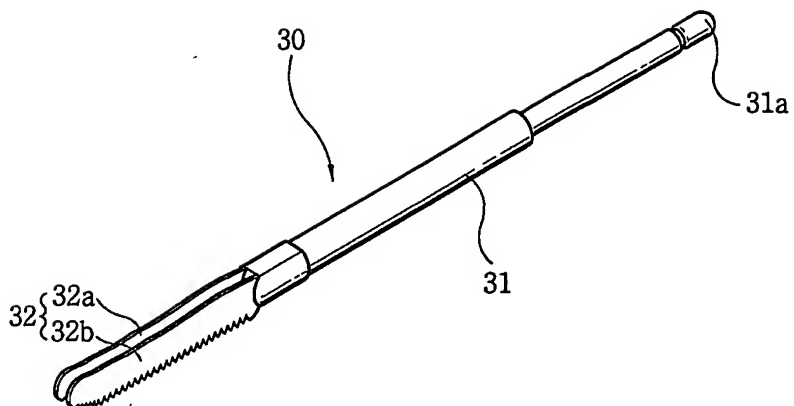
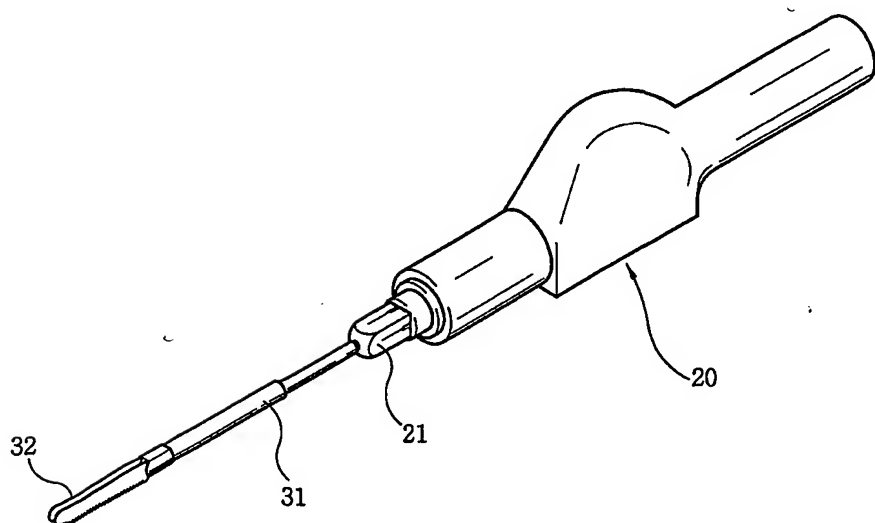
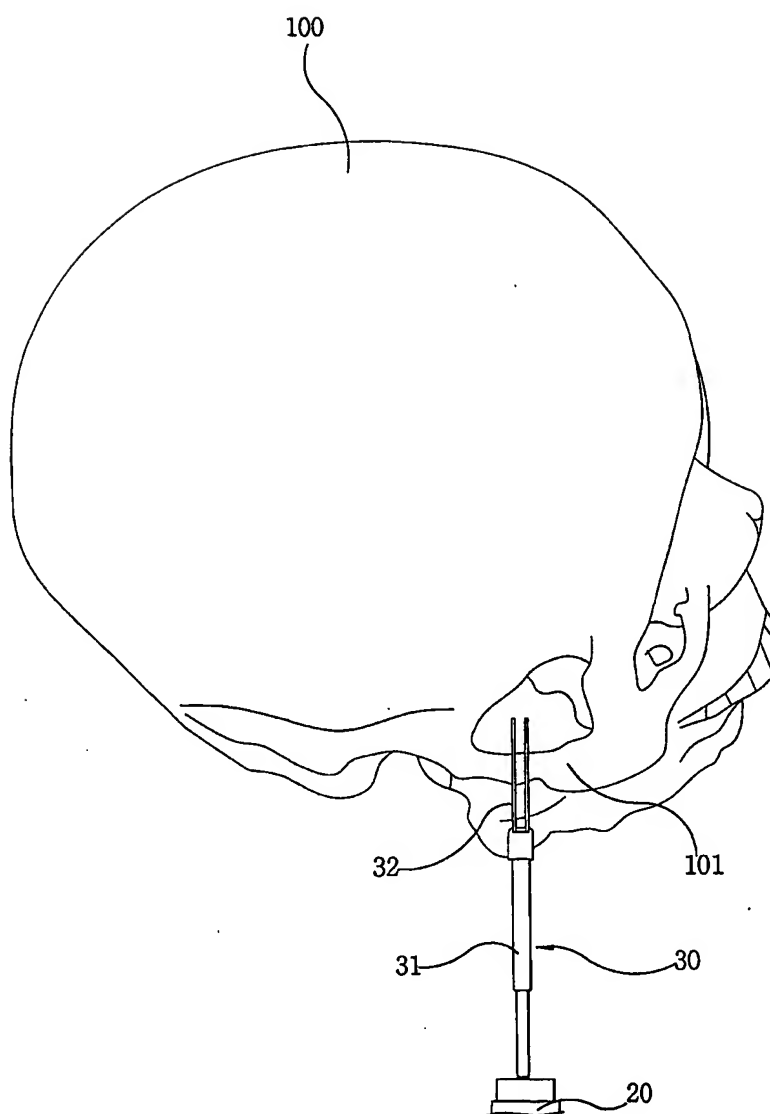


Fig.5



4/5  
Fig.6



5/5  
Fig.7

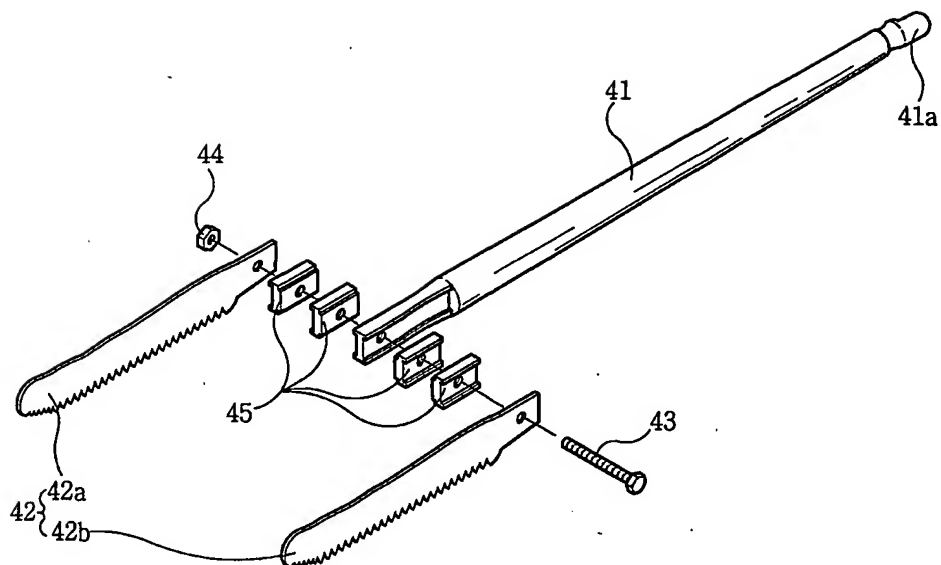
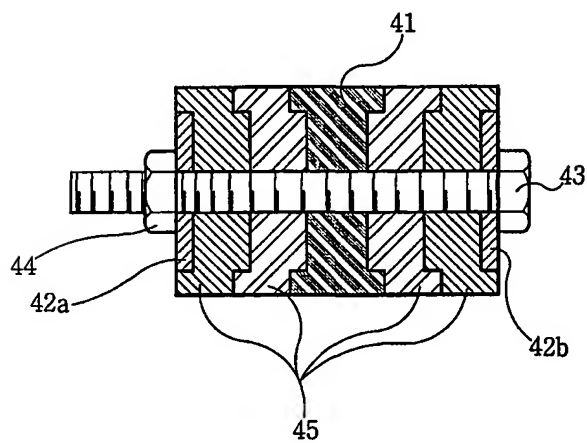


Fig.8



## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/KR01/01504**A. CLASSIFICATION OF SUBJECT MATTER****IPC7 A61B 17/16**

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

A61B 17/14, 17/15, 17/16, 17/17

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and Utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| A         | US5846244A(Phil Cripe) 8 DEC. 1998 (8.12.1998), See Entire Document.               | 1-5                   |
| A         | US6007541A(Tony D. Scott) 28 DEC. 1999 (28.12.1999), See Entire Document.          | 1-5                   |
| A         | EP0517529A2(Inoue, Kiyoshi) 5 JUNE 1992 (5. 6. 1992) , See Entire Document.        | 1-5                   |
| A         | US4036236A(Earl H. Rhodes) 19 JULY 1977 (19. 7. 1977), See Entire Document.        | 1-5                   |

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

22 DECEMBER 2001 (22.12.2001)

Date of mailing of the international search report

26 DECEMBER 2001 (26.12.2001)

Name and mailing address of the ISA/KR  
Korean Intellectual Property Office

Facsimile No.

Authorized officer

WON, Jong Dai

Telephone No.



**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.  
PCT/KR01/01504

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)                                | Publication<br>date  |
|---|---------------------|---|--|
| US5846244A                                | DEC. 8, 1998        | WO9710765A1<br>JP11512624T2<br>EP0853464A1<br>AU7112696A1 | March 27, 1997<br>Nov. 2, 1999<br>July 22, 1998<br>April 9, 1997 |
| US6007541A                                | DEC. 28, 1999       | NONE  |  |
| EP0517529A2                               | JUNE. 5, 1992       | NONE  |  |
| US4036236A                                | JULY. 19, 1977      | NONE  |  |



(19)



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(11)

**EP 0 716 831 B1**

(12)

**EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention  
of the grant of the patent:  
17.03.1999 Bulletin 1999/11

(51) Int. Cl.<sup>6</sup>: **A61B 17/14**, **B23B 31/22**,  
**B23D 51/10**

(21) Application number: **95203449.4**

(22) Date of filing: **12.12.1995**

**(54) Surgical cutting device with safety interlock**

Chirurgische Schneidevorrichtung mit Sicherheitsverriegelung

Appareil chirurgical coupant équipé d'un verrouillage de sécurité

(84) Designated Contracting States:  
**DE FR GB IT**

(30) Priority: **13.12.1994 US 355387**

(43) Date of publication of application:  
19.06.1996 Bulletin 1996/25

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(56) References cited:  
**EP-A- 0 607 883** **DE-A- 3 500 445**  
**US-A- 5 222 956**

- Zimmer sales booklet entitled "THE HALL STERNUM SAW" printed 1990 in the USA, Hall Surgical (Lit. N. 97-5059-401); Zimmer instruction manual "THE HALL VERSIPOWER STERNUM SAW", printed 1991 in the USA, Hall Surgical (Lit. N. HS 22-17446-00).

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

**EP 0 716 831 B1**

## Description

### BACKGROUND OF THE INVENTION

#### FIELD OF THE INVENTION

[0001] This invention relates generally to powered surgical cutting devices. More particularly, this invention relates to powered surgical blades and means for joining these blades to a surgical handpiece. Still more particularly, this invention relates to a powered sternum saw provided with a guard and a safety interlock to prevent operation of the saw unless all parts are properly assembled.

#### DESCRIPTION OF THE PRIOR ART

[0002] Surgical saws are well known for cutting various types of tissue during surgical procedures. The saws are often provided with shields or guards to prevent inadvertent damage to tissue adjacent the surgical work site. Such guards are particularly important when using powered surgical saws.

[0003] One type of known surgical cutting device is a sternum saw which is, as the name implies, used for cutting through the sternum during a surgical procedure. A collet mechanism is provided to secure the reciprocating saw blade to the handpiece and the collet nut is tightened with a wrench or other tool in order to hold the flat "saber saw" in a longitudinally reciprocating drive shaft. The collet not only grips the saw blade but also acts to squeeze a locking alignment ball into a hole formed in the proximal end of the blade in order to prevent the blade from falling out of the handpiece should the collet become loose. Because of the sensitive location of the sternum such surgical saws are generally provided with a saw blade guard in order to partially enclose the reciprocating saw blade to preclude it from accidentally cutting unintended tissue. However, the presence of the guard limits access to the collet nut and makes it more difficult to tighten the blade. Additionally, the need to keep track of a separate tool or wrench to tighten the collet adds to the difficulty. Further guidance to the prior art is given in the description with reference to the drawings in Figures 4 and 5, and has been published in a Zimmer instruction manual entitled "The®Hall Versipower Sternum Saw", Lit n°. HS 22-17446-00, 1991 HALL SURGICAL, USA. Improvements in design are desirable to facilitate the assembly of the blade onto the handpiece. In addition to facilitating attachment of the saw blade to the handpiece, it is always desirable to incorporate additional safety features in powered surgical saws. Consequently, it is the object of this invention to produce a powered surgical saw with a means for attaching the saw blade to the handpiece without using an extra tool. Such a handpiece will be sometimes referred to as a "wrench-less" handpiece.

[0004] It is another object of this invention to provide a sternum saw with a sternum safety guard which necessarily has to be in proper position in order to enable operation of the saw.

5 [0005] It is also object of this invention to provide a safety interlock which requires all components of the powered surgical saw to be properly assembled before the saw can effectively cut tissue.

10 [0006] It is yet another object of this invention to produce, in a powered surgical saw, a safety interlock which simultaneously locks and properly positions a blade and a blade guard.

#### SUMMARY OF THE INVENTION

15

[0007] These objects are achieved by the invention as defined in the appended claims which specify a method of connecting a surgical saw and a surgical saw for use with an elongated surgical blade having a proximal end, a distal end and at least one notch detent at the proximal end. The saw comprises a housing or handpiece having an opening at its distal end and a drive shaft having an end adjacent the opening for receiving the surgical blade. The handpiece includes a means for driving the drive shaft. A blade receiving means at the end of the drive shaft comprises a first locking-ball holding means situated on the drive shaft for holding the proximal end of the surgical blade. The balls of the first locking-ball holding means are held in the notch of the surgical blade by a cylindrical cam ring attached to the base of the blade guard. An outer surface of the cam ring is provided with an annular groove which operates with the balls of a second locking-ball holding means situated on the handpiece. A cylindrical collar means on the handpiece holds the balls of the second locking-ball holding means in the annular groove and thereby locks the blade and the guard in proper position.

20

[0008] The method of connecting a surgical cutting blade to a power source for driving the device comprises the steps of providing a surgical cutting device having a notch detent at its proximal end, providing a first locking-ball holding means to hold the device to the power source and holding the cutting device and the first locking-ball holding means in locked position with a cam ring which is itself locked in place by a second locking-ball holding means.

25

#### BRIEF DESCRIPTION OF THE DRAWINGS

30

[0009]

Figure 1 is a cross-sectional view of a sternum saw constructed in accordance with the principles of this invention.

35

Figure 2 is an exploded diagrammatic view of the distal end of Figure 1.

Figure 3 is a cross-sectional view of Figure 2 taken along the line 3-3.

Figure 4 is a cut-away cross-sectional side elevation view of a portion of the distal end of a prior art surgical saw showing a known collet mechanism for holding a saw blade.

Figure 5 is a cross-sectional view of Figure 4 taken along the line 5-5.

Figure 6 is a view of Figure 2 showing the components partially assembled.

Figure 7 is a cross-sectional view of Figure 6 taken along the line 7-7.

Figure 8 is a side elevation view of the saw guard of Figure 1.

Figure 9 is a top plan view of Figure 8.

Figure 10 is a view of Figure 8 taken along the line 10-10.

#### **DESCRIPTION OF THE PREFERRED EMBODIMENT**

[0010] Referring now to Figures 1 and 2, powered surgical saw 1 is shown comprising a "wrench-less" handpiece 2 having a battery receptacle 3 (to receive a battery, not shown), motor 4, trigger 5, motor output shaft 6, drive shaft 7 and a distal working end 8 to which a sternum saw blade 9 and guard 10 are attached. Most of the foregoing components are conventional and form no part of this invention. The invention relates to the distal end 8 and the manner in which blade 9 and guard 10 are attached to handpiece 2.

[0011] For comparison and explanatory purposes, the distal end 20 of a prior art handpiece is shown in Figure 4. It will be understood that the distal end 8 of handpiece 2 in Figure 1 is comparable in function to prior art distal end 20 and, therefore, the proximal end of handpiece 2 (to the right of distal end 8 in Figure 1) may be used in a prior art handpiece to drive distal end 20. The prior art distal end 20 comprises a collet/output shaft assembly 22 having a blade receiving collet 24 threaded on the distal end of drive shaft 26, an annular, guard receiving chamber 28 surrounding collet 24 and a guard locking mechanism 30. Blade receiving collet 24 comprises a threaded collet tip 25 provided with a nut 25A, a flat, blade receiving opening 31 (in the plane of the paper) and a ball 33 intended to be received within a corresponding alignment aperture 35 of a surgical saw blade. As will be understood below, one advantage of the invention is that saw blades made for use with the new "wrench-less" handpiece may continue to include alignment aperture 35 for use with a prior art handpiece (depending on user preference). Collet 24 is operated in a conventional manner by being tightened by the turning of the nut to clamp and frictionally engage the saw blade. Annular guard receiving chamber 28 is provided to receive the base of a sternum guard similar to that shown in Figures 1 and 2 and in greater detail in Figures 8-10. The guard is retained in chamber 28 by locking mechanism 30 which relies on the interaction of three annularly spaced locking balls 32 with a cam ring in the form of retractable, spring-loaded, cylindrical locking

collar 34 in a conventional manner. Spring 37 urges collar 34 distally to lock balls 32 within an associated annular groove of the base of the guard. As best seen in Figures 4 and 5, annular chamber 28 is provided with three locking balls 32 and a pair of diametrically opposed keys 36 in order to properly orient the guard relative to the blade as will be understood below. It should be noted that the prior art collet/output shaft assembly 22 operates independently of locking mechanism 30. As will be understood, the invention described below makes proper functioning of a new collet/output shaft assembly dependent upon the guard locking mechanism.

[0012] The invention will now be described with reference to a new collet/output shaft assembly 50 best seen in Figures 1, 2, 6 and 7. The invention produces a "wrench-less" design by enabling a slightly modified guard and saw blade to be attached to a handpiece without the use of any auxiliary tools to tighten a collet as in the prior art device. In Figure 2, the distal end 52 of collet/output shaft assembly 50 is shown in exploded association with saw blade 9 and guard 10. In Figure 6, the components are shown partially assembled to show the operation of the safety locking mechanism. The proximal portion of collet/output shaft assembly 50 (not shown) is similar to that of prior art collet/output shaft assembly 22 and does not need to be described to understand the present invention.

[0013] Collet/output shaft assembly 50 comprises a reciprocating cylindrical drive shaft 60 provided with an inner locking ball holding mechanism 62 near its distal end 64. Locking ball holding mechanism 62 comprises a pair of diametrically opposed retaining balls 66 situated in restricted apertures in drive shaft 60 in a conventional manner. A ball retaining insert 68 is provided to prevent the balls from falling into the interior of drive shaft 60 when blade 9 is not in position. The distal end of insert 68 is provided with a diametrical slit 70 designed to receive the proximal end of flat blade 9 in aligned orientation relative to balls 66.

[0014] Saw blade 9 and guard 10 are slightly modified versions of the prior art components in order to enable them to work in the invention hereof. Blade 9 is a conventional saber saw type reciprocating surgical blade modified by having notches 80 formed on opposite sides of the blade shaft. Aperture 35, best seen in Figure 2, is used in blade 9 even though it has no function in the invention and is only provided to make blade 9 usable in prior art handpieces. Notches 80 are spaced a predetermined distance distally from the proximal end 82 of blade 9 and, as will be understood below, are intended to receive balls 66 when blade 9 is properly seated within collet/output shaft assembly 50.

[0015] Guard 10, best seen in Figures 8-10, comprises a ball locking cam in the form of cylindrical cam ring base portion 90, a connecting arm 92 and a slotted, distal guard head 94. Cylindrical base 90 has an outer diameter adapted to fit annular chamber 28a surround-

ing the distal end of drive shaft 60 and includes in its outer surface an annular groove 96 which is adapted to receive locking balls 32a of locking ball holding mechanism 30a. A pair of diametrically opposed keyways 99 (only one of which is seen in Figure 8) is provided to engage keys 36 (best seen in Figure 5). A cylindrical insert 98 is utilized to modify the prior art guard design to assure the inside diameter of base 90 is approximately equal to the outside diameter of shaft 60. The inner surface of insert 98 serves as a bearing surface for balls 66 during operation of the saw. Alternatively, the guard base could be made as an integral piece having the appropriate inner diameter. The locking ball holding mechanism 30a of collet/output shaft assembly 50 is essentially identical to the locking ball retaining mechanism 30 of the prior art device shown in Figure 4.

[0016] It will be understood that as the components shown in Figure 2 are assembled together, with blade 9 first being inserted into slot 70 at the end of drive shaft 60, balls 66 are pushed radially outwardly as best seen in Figures 6 and 7 into guard receiving chamber 28a by the opposed lateral edges of the proximal end of blade 9. When the blade is fully pushed into proper position as best seen in Figure 1, balls 66 will fall into notches 80. Once the blade is thus properly positioned, the base 90 of guard 10 will be able to be inserted into guard receiving chamber 28a. If blade 9 is not properly positioned, balls 66 will interfere with the guard and prevent base 90 from fully entering annular chamber 28a. When guard 10 is fully seated, outer balls 32a will fall into annular groove 96 in order to lock guard 10 within distal end 8 while enabling the collet/output shaft assembly 50 to reciprocate. It will be understood that the action of locking guard 10 within chamber 28a also locks blade 9 by virtue of trapping balls 66 in notches 80. The base of guard 10, therefore, is essentially an intermediate cam surface acting upon both the blade and the guard locking mechanism.

[0017] While the invention is disclosed with respect to a surgical cutting device in the form of a flat and reciprocating saber type saw blade, other modifications of the invention may be made to make it suitable for other types of cutting blades with or without associated guard devices. For example, the invention may be adaptable to rotating arthroscopic shavers having elongated, relatively rotating surgical shaver blades.

[0018] As an additional safety feature (best seen in Figure 6) the cylindrical locking ring 34a may be provided with a notch 100 in its proximal annular edge 102 and the body of distal end 8 of the handpiece could be provided with a radially outwardly extending pin 104. The longitudinal placement of pin 104 is such that ring 34a must be rotated to align notch 100 with pin 104 in order to enable ring 34a to be retracted.

[0019] It will be understood that numerous other improvements and modifications may be made to the preferred embodiment disclosed herein without departing from the scope of the invention as defined in the

appended claims.

## Claims

1. A surgical saw system comprising:

an elongated surgical blade (9) having a proximal end (82), a distal end and at least one notch detent (80) at the proximal end (82);  
a housing (2) having an opening for receiving said surgical blade (9);  
a drive shaft (60) having an end (64) adjacent said opening;  
means (4) for driving said drive shaft (60);  
blade receiving means at the end (64) of said drive shaft (60) for receiving said surgical blade (9), said blade receiving means comprising first locking-ball holding means (62) having at least one ball (66) situated on said drive shaft (60) adjacent said end (64) thereof for engaging in said at least one notch (80) at said proximal end (82) of said surgical blade (9);  
a first cylindrical cam ring means (90) for cooperative engagement with said first locking-ball holding means (62), said cylindrical cam ring means (90) comprising an inner surface for urging said at least one ball (66) of said first locking-ball holding means (62) into said at least one notch (80) of said surgical blade (9), and an outer surface provided with an annular groove (96);  
cam ring receiving means (28a) for receiving said first cylindrical cam ring means (90), said cam ring receiving means (28a) comprising a second locking-ball holding means (30a) having at least one ball (32a) situated on said housing (2) for engaging said annular groove (96);  
a second cylindrical cam ring means movably situated on said housing (2) for cooperative engagement with said second locking-ball holding means (30a), said second cylindrical cam ring means comprising a collar (34a) having an inner surface for urging at least one ball (32a) of said second locking-ball holding means (30a) into said annular groove (96); and  
means to hold said second cylindrical cam ring means fixed to thereby hold said at least one ball (32a) of said second locking-ball holding means (30a) in said annular groove (96).

2. A surgical saw according to claim 1, further comprising:

an elongated blade guard (10) extending distally from said first cylindrical cam ring means (90).

3. A surgical saw according to Claim 1, wherein said surgical blade (9) is a flat saber saw blade and said at least one notch (80) is formed in one edge thereof, proximal to the cutting edge. 5
4. A surgical saw according to Claim 3, wherein said surgical blade (9) has two notches (80), one in each of two parallel edges proximal to the cutting edge, and wherein said first locking-ball holding means comprises two balls (66), each adapted to fit in a corresponding notch (80). 10
5. A surgical saw according to claim 1, wherein said drive shaft (60) is provided with two diametrically opposed locking balls (66) and ball-receiving apertures (62). 15
6. A surgical saw according to claim 1, wherein said second locking-ball holding means (30a) comprises: 20
  - a second plurality of locking balls (32a) and corresponding ball receiving apertures spaced about said housing (2); and
  - ball receiving means (96) on said cam lock cylindrical body portion (90). 25
7. A method of connecting a surgical cutting device (9) to a power source (4) having a drive shaft (60) for driving the surgical cutting device (9) comprising the steps of: 30
  - providing an elongated surgical cutting device (9) having at least one notch detent (80) at its proximal end (82); 35
  - providing a first locking-ball holding means (62) for holding said cutting device (9) relative to the drive shaft (60);
  - placing said at least one notch detent (80) of said cutting device (9) adjacent said first locking-ball holding means (62) to nest at least one ball (66) thereof into said at least one notch detent (80); 40
  - locking said first locking-ball holding means (62) to said at least one notch (80) with a locking cam (90); 45
  - providing a second locking-ball holding means (30a) for holding said locking cam (90) relative to said housing (2); and
  - locking said locking cam (90) with said second locking-ball holding means (30a). 50
8. A method according to claim 7, wherein the step of locking said first locking ball holding means (62) enables said at least one ball (66) of said first locking-ball holding means (62) to move to facilitate longitudinally reciprocal motion of said drive shaft (60). 55
9. A method according to claim 7, wherein the step of providing an elongated surgical cutting device (9) having at least one notch (80) at its proximal end (82) further comprises the step of providing a flat blade having a pair of notches in opposing, longitudinally extending edges.
10. A surgical saw for use with an elongated surgical cutting device (9) having at least one notch detent (80) at one end thereof, said surgical saw having a housing (2) and a drive shaft (60), said drive shaft provided with a receiving means at an end (64) thereof for receiving said surgical cutting device (9), comprising:
  - a radially inner, first locking-ball retaining means (62) for releasably retaining said elongated cutting device (9) to and in alignment with said drive shaft (60), said first locking-ball holding means comprising a plurality of locking balls (66) and corresponding ball-receiving apertures spaced about said drive shaft (60);
  - a cutting device guard (10) for surrounding a predetermined portion of said elongated cutting device (9), said guard provided with a cylindrical base portion (90);
  - a radially outer, second locking-ball holding means (30a) for releasably retaining said guard (10) to said housing (2), said second locking-ball holding means comprising a plurality of locking balls (32a) and corresponding ball-receiving apertures spaced about said housing;
  - an intermediate cylindrical cam surface means interposed between said cylindrical base portion (90) and said drive shaft (60) for simultaneously locking said first locking-ball holding means (62) to secure said surgical cutting device (9) to said drive shaft (60) and providing means cooperative with said second locking ball holding means to secure said cylindrical base portion (90) to said housing (2).

#### Patentansprüche

##### 1. Chirurgisches Sägensystem mit:

einem länglichen chirurgischen Blatt (9) mit einem proximalen Ende (82), einem distalen Ende und mindestens einer Kerbarretierung (80) am proximalen Ende (82);  
 einem Gehäuse (2) mit einer Öffnung (8) zum Aufnehmen des chirurgischen Blatts (9);  
 einer Antriebswelle (60) mit einem zur Öffnung benachbarten Ende (64);  
 einer Einrichtung (4) zum Antreiben der Antriebswelle (60);  
 einer Blattaufnahmeeinrichtung am Ende (64)

- der Antriebswelle (60) zum Aufnehmen des chirurgischen Blatts (9), wobei die Blattaufnahmeeinrichtung aufweist: eine erste Sperrkugel-Halteeinrichtung (62) mit mindestens einer Kugel (66), die an der Antriebswelle (60) benachbart zu ihrem Ende (64) angeordnet ist, zum Eingreifen in die mindestens eine Kerbe (80) an dem proximalen Ende (82) des chirurgischen Blatts;
- einer ersten zylindrischen Nockenringeinrichtung (90) zum Zusammenwirkenden Eingriff mit der ersten Sperrkugel-Halteeinrichtung (62), wobei die zylindrische Nockenringeinrichtung (90) aufweist: eine Innenfläche zum Drücken der mindestens einen Kugel (66) der ersten Sperrkugel-Halteeinrichtung (62) in die mindestens eine Kerbe (80) des chirurgischen Blatts (9) und eine mit einer ringförmigen Nut (96) versehene Außenfläche;
- einer Nockenring-Aufnahmeeinrichtung (28a) zum Aufnehmen der ersten zylindrischen Nockenringeinrichtung (90), wobei die Nockenring-Aufnahmeeinrichtung (28a) eine zweite Sperrkugel-Halteeinrichtung (30a) mit mindestens einer an dem Gehäuse (2) angeordneten Kugel (32a) zum Eingreifen in die ringförmige Nut (96) aufweist;
- einer zweiten zylindrischen Nockenringeinrichtung, die beweglich an dem Gehäuse (2) zum zusammenwirkenden Eingriff mit der zweiten Sperrkugel-Halteeinrichtung (30a) angeordnet ist, wobei die zweite zylindrische Nockenringeinrichtung aufweist: einen Bund (34a) mit einer Innenfläche zum Drücken mindestens einer Kugel (32a) der zweiten Sperrkugel-Halteeinrichtung (30a) in die ringförmige Nut (96); und
- einer Einrichtung, um die zweite zylindrische Nockenringeinrichtung fixiert zu halten, um dadurch die mindestens eine Kugel (32a) der zweiten Sperrkugel-Halteeinrichtung (30a) in der ringförmigen Nut (96) zu halten.
2. Chirurgische Säge nach Anspruch 1, ferner mit:
- einem länglichen Blattschutz (10), der sich distal von der ersten zylindrischen Nockenringeinrichtung (90) erstreckt.
3. Chirurgische Säge nach Anspruch 1, wobei das chirurgische Blatt (9) ein flaches Stichsägeblatt ist und die mindestens eine Kerbe (80) in einer Kante davon proximal zur Schneidkante ausgebildet ist.
4. Chirurgische Säge nach Anspruch 3, wobei das chirurgische Blatt (9) zwei Kerben (80) hat, eine in jeder von zwei parallelen Kanten proximal zur Schneidkante, und wobei die erste Sperrkugel-Halteeinrichtung zwei Kugeln (66) aufweist, die jeweils geeignet sind, sich in eine entsprechende Kerbe (80) einzupassen.
5. Chirurgische Säge nach Anspruch 1, wobei die Antriebswelle (60) mit zwei diametral entgegengesetzten Sperrkugeln (66) und Kugelaufnahmeöffnungen (62) versehen ist.
6. Chirurgische Säge nach Anspruch 1, wobei die zweite Sperrkugel-Halteeinrichtung (30a) aufweist:
- mehrere zweite Sperrkugeln (32a) und entsprechende Kugelaufnahmeöffnungen, die um das Gehäuse (2) beabstandet sind; und
- eine Kugelaufnahmeeinrichtung (96) an dem zylindrischen Nockensperren-Körperabschnitt (90).
7. Verfahren zum Verbinden einer chirurgischen Schneidvorrichtung (9) mit einer Kraftquelle (4), die eine Antriebswelle (60) zum Antreiben der chirurgischen Schneidvorrichtung (9) hat, mit den folgenden Schritten:
- Bereitstellen einer länglichen chirurgischen Schneidvorrichtung (9) mit mindestens einer Kerbarretierung (80) an ihrem proximalen Ende (82);
- Bereitstellen einer ersten Sperrkugel-Halteeinrichtung (62) zum Halten der Schneidvorrichtung (9) relativ zur Antriebswelle (60);
- Anordnen der mindestens einen Kerbarretierung (80) der Schneidvorrichtung (9) benachbart zu der ersten Sperrkugel-Halteeinrichtung (62), um mindestens eine Kugel (66) davon in die mindestens eine Kerbarretierung (80) einrasten zu lassen;
- Sperren der ersten Sperrkugel-Halteeinrichtung (62) an der mindestens einen Kerbe (80) mit einer Sperrnocke (90);
- Bereitstellen einer zweiten Sperrkugel-Halteeinrichtung (30a) zum Halten der Sperrnocke (90) relativ zu dem Gehäuse (2); und
- Sperren der Sperrnocke (90) mit der zweiten Sperrkugel-Halteeinrichtung (30a).
8. Verfahren nach Anspruch 7, wobei sich durch den Schritt zum Sperren der ersten Sperrkugel-Halteeinrichtung (62) die mindestens eine Kugel (66) der ersten Sperrkugel-Halteeinrichtung (62) bewegen kann, um eine hin- und hergehende Längsbewegung der Antriebswelle (60) zu erleichtern.
9. Verfahren nach Anspruch 7, wobei der Schritt zum Bereitstellen einer länglichen chirurgischen Schneidvorrichtung (9) mit mindestens einer Kerbe (80) an ihrem proximalen Ende fern r den Schritt

zum Bereitstellen eines flachen Blatts mit einem Paar Kerben in gegenüberliegenden, sich längs erstreckenden Kanten aufweist.

10. Chirurgische Säge zur Verwendung mit einer länglichen chirurgischen Schneidvorrichtung (9) mit mindestens einer Kerbarretierung (80) an einem Ende davon, wobei die chirurgische Säge ein Gehäuse (2) und eine Antriebswelle (60) hat, die Antriebswelle mit einer Aufnahmeeinrichtung an einem Ende (64) davon zum Aufnehmen der chirurgischen Schneidvorrichtung (9) versehen ist, mit:

einer radial innenliegenden, ersten Sperrkugel-Festhalteeinrichtung (62) zum lösbaren Festhalten der länglichen Schneidvorrichtung (9) an der Antriebswelle (60) und in Ausrichtung zu ihr, wobei die erste Sperrkugel-Halteeinrichtung mehrere Sperrkugeln (66) und entsprechende Kugelaufnahmeöffnungen aufweist, die um die Antriebswelle (60) beabstandet sind; einem Schneidvorrichtungsschutz (10) zum Umschließen eines vorbestimmten Abschnitts der länglichen Schneidvorrichtung (9), wobei der Schutz mit einem zylindrischen Basisabschnitt (90) versehen ist; einer radial außenliegenden, zweiten Sperrkugel-Halteeinrichtung (30a) zum lösbaren Festhalten des Schutzes (10) an dem Gehäuse (2), wobei die zweite Sperrkugel-Halteeinrichtung mehrere Sperrkugeln (32a) und entsprechende Kugelaufnahmeöffnungen aufweist, die um das Gehäuse beabstandet sind; einer dazwischenliegenden zylindrischen Nockenflächeneinrichtung, die zwischen den zylindrischen Basisabschnitt (90) und die Antriebswelle (60) eingefügt ist, zum gleichzeitigen Sperren der ersten Sperrkugel-Halteeinrichtung (62), um die chirurgische Schneidvorrichtung (9) an der Antriebswelle (60) zu befestigen, und Bereitstellen einer mit der zweiten Sperrkugel-Halteeinrichtung zusammenwirkenden Einrichtung, um den zylindrischen Basisabschnitt (90) an dem Gehäuse (2) zu befestigen.

## Revendications

1. Système de scie chirurgicale comprenant :

une lame chirurgicale oblongue (9) ayant une extrémité proximale (82), une extrémité distale et au moins un positionneur d'encoche (80) à l'extrémité proximale (82) ;  
un logement (2) ayant une ouverture (8) pour recevoir ladite lame chirurgicale (9) ;  
un arbre d'entraînement (60) ayant une extrémité (64) adjacente à ladite ouverture (8 ; 98) ;

un moyen (4) pour entraîner ledit arbre d'entraînement (60) ;

un moyen de réception de lame à l'extrémité (64) dudit arbre d'entraînement (60) pour recevoir ladite lame chirurgicale (9), ledit moyen de réception de lame comprenant un premier moyen de maintien de billes de verrouillage (62) comportant au moins une bille (66) située sur ledit arbre d'entraînement (60) adjacent à ladite extrémité (64) de celui-ci pour s'engager dans ladite au moins une encoche (80) à ladite extrémité proximale (82) de ladite lame chirurgicale (9) ;

un premier moyen de bague de came cylindrique (90) pour une mise en prise de coopération avec ledit premier moyen de maintien de billes de verrouillage 62, ledit moyen de bague de came cylindrique (90) comprenant une surface interne pour solliciter ladite au moins une bille (66) dudit premier moyen de maintien de billes de verrouillage (62) dans ladite au moins une encoche (80) de ladite lame chirurgicale (9), et une surface extérieure pourvue d'une rainure annulaire (96) ;

un moyen de réception de bague de came (28a) pour recevoir ledit premier moyen de bague de came cylindrique (90), ledit moyen de réception de bague de came (28a) comprenant un deuxième moyen de maintien de billes de verrouillage (30a) ayant au moins une bille (32a) située sur ledit logement (2) pour s'engager dans ladite rainure annulaire (96) ;

un deuxième moyen de bague de came cylindrique située de manière mobile sur ledit logement (2) pour une mise en prise de coopération avec ledit deuxième moyen de maintien de billes de verrouillage (30a), ledit deuxième moyen de bague de came cylindrique comprenant un collier (34a) ayant une surface interne pour solliciter au moins une bille (32a) dudit deuxième moyen de maintien de billes de verrouillage (30a) dans ladite rainure annulaire (96) ; et

un moyen pour maintenir ledit deuxième moyen de bague de came cylindrique à l'état fixé pour retenir ainsi ladite au moins une bille (32a) dudit deuxième moyen de maintien de billes de verrouillage (30a) dans ladite rainure annulaire (96).

2. Scie chirurgicale selon la revendication 1, comprenant en outre :

une protection de lame oblongue (10) s'étendant distalement dudit premier moyen de bague de came cylindrique (90).

3. Scie chirurgicale selon la revendication 1, où ladite

lame chirurgicale (9) est une lame de scie de sabre plate, et ladite au moins une encoche (80) est ménagée dans un bord de celle-ci, proche du bord coupant.

4. Scie chirurgicale selon la revendication 3, où ladite lame chirurgicale (9) a deux encoches (80), une dans chacun des deux bords parallèles proche du bord coupant, et où ledit premier moyen de maintien de billes de verrouillage comprend deux billes (66), chacune apte à s'ajuster dans une encoche correspondante (80). 5
5. Scie chirurgicale selon la revendication 1, où ledit arbre d'entraînement (60) présente deux billes de verrouillage (66) diamétralement opposées et ouvertures de réception de billes (62). 10
6. Scie chirurgicale selon la revendication 1, où ledit deuxième moyen de maintien de billes de verrouillage (30a) comprend : 20
  - une deuxième pluralité de billes de verrouillage (32a) et des ouvertures de réception de bille correspondantes espacées autour dudit logement (2) ; et 25
  - un moyen de réception de billes (96) sur ladite portion de corps cylindrique de verrouillage de came (90). 30
7. Procédé pour connecter un dispositif coupant chirurgical (9) à une source de puissance (4) comportant un arbre d'entraînement (60) pour entraîner le dispositif chirurgical coupant (9), comprenant les étapes consistant à : 35
  - réaliser un dispositif chirurgical coupant oblong (9) ayant au moins un positionneur d'encoche (80) à son extrémité proximale (82) ;
  - réaliser un premier moyen de maintien de billes de verrouillage (62) pour tenir ledit dispositif coupant (9) relativement à l'arbre d'entraînement (60); 40
  - placer ledit au moins un positionneur d'encoche (80) dudit dispositif coupant (9) pour qu'il soit adjacent audit premier moyen de maintien de billes de verrouillage (62) pour nicher au moins une bille (66) de celui-ci dans ledit au moins un positionneur d'encoche (80) ; 45
  - verrouiller ledit premier moyen de maintien de billes de verrouillage (62) à ladite au moins une encoche (80) avec une came de verrouillage (90) ; 50
  - réaliser un deuxième moyen de maintien de billes de verrouillage (30a) pour tenir ladite came de verrouillage (90) relativement audit logement (2) ; et 55
  - verrouiller ladite came de verrouillage (90)

avec ledit deuxième moyen de maintien de billes de verrouillage (30a).

8. Procédé selon la revendication 7, où l'étape consistant à verrouiller ledit premier moyen de maintien de billes de verrouillage (62) permet à ladite au moins une bille (66) dudit premier moyen de maintien de billes de verrouillage (62) de se déplacer pour faciliter un mouvement longitudinal de va-et-vient dudit arbre d'entraînement (60). 10
9. Procédé selon la revendication 7, dans lequel l'étape consistant à réaliser un dispositif chirurgical coupant oblong (9) ayant au moins une encoche (80) à son extrémité proximale (82) comprend en outre l'étape consistant à réaliser une lame plate ayant une paire d'encoches dans des bords opposés, s'étendant longitudinalement.
10. Scie chirurgicale prévue pour être utilisée avec un dispositif chirurgical coupant oblong (9) présentant au moins un positionneur d'encoche (80) à une extrémité de celui-ci, ladite scie chirurgicale ayant un logement (2) et un arbre d'entraînement (60), ledit arbre d'entraînement étant pourvu d'un moyen de réception à une extrémité (64) de celui-ci pour recevoir ledit dispositif chirurgical coupant (9), comprenant : 20
  - un premier moyen de maintien de billes de verrouillage (62) radialement intérieur pour retenir relâchement ledit dispositif coupant oblong (9) à et en alignement avec ledit arbre d'entraînement (60), ledit premier moyen de maintien de Des de verrouillage comprenant une pluralité de billes de verrouillage (66) et des ouvertures de réception de bille correspondantes espacées autour dudit arbre d'entraînement (60) ; 30
  - une protection (10) du dispositif coupant pour entourer une partie prédéterminée dudit dispositif coupant oblong (9), ladite protection présentant une portion de base cylindrique (90) ;
  - un deuxième moyen de maintien de billes de verrouillage (30a), radialement extérieur, pour retenir relâchement ladite protection (10) audit logement (2), ledit deuxième moyen de maintien de billes de verrouillage comprenant une pluralité de billes de verrouillage (32a) et des ouvertures de réception de bille correspondantes espacées autour dudit logement ; 40
  - un moyen de surface de came cylindrique intermédiaire interposé entre ladite portion de base cylindrique (90) et ledit arbre d'entraînement (60) pour le verrouillage simultané dudit premier moyen de maintien de billes de verrouillage (62) pour fixer ledit dispositif chirurgical coupant (9) audit arbre d'entraînement 50



ment (60) et pour réaliser un moyen coopérant avec ledit deuxième moyen de maintien de billes de verrouillage pour fixer ladite portion de base cylindrique (90) audit logement (2).

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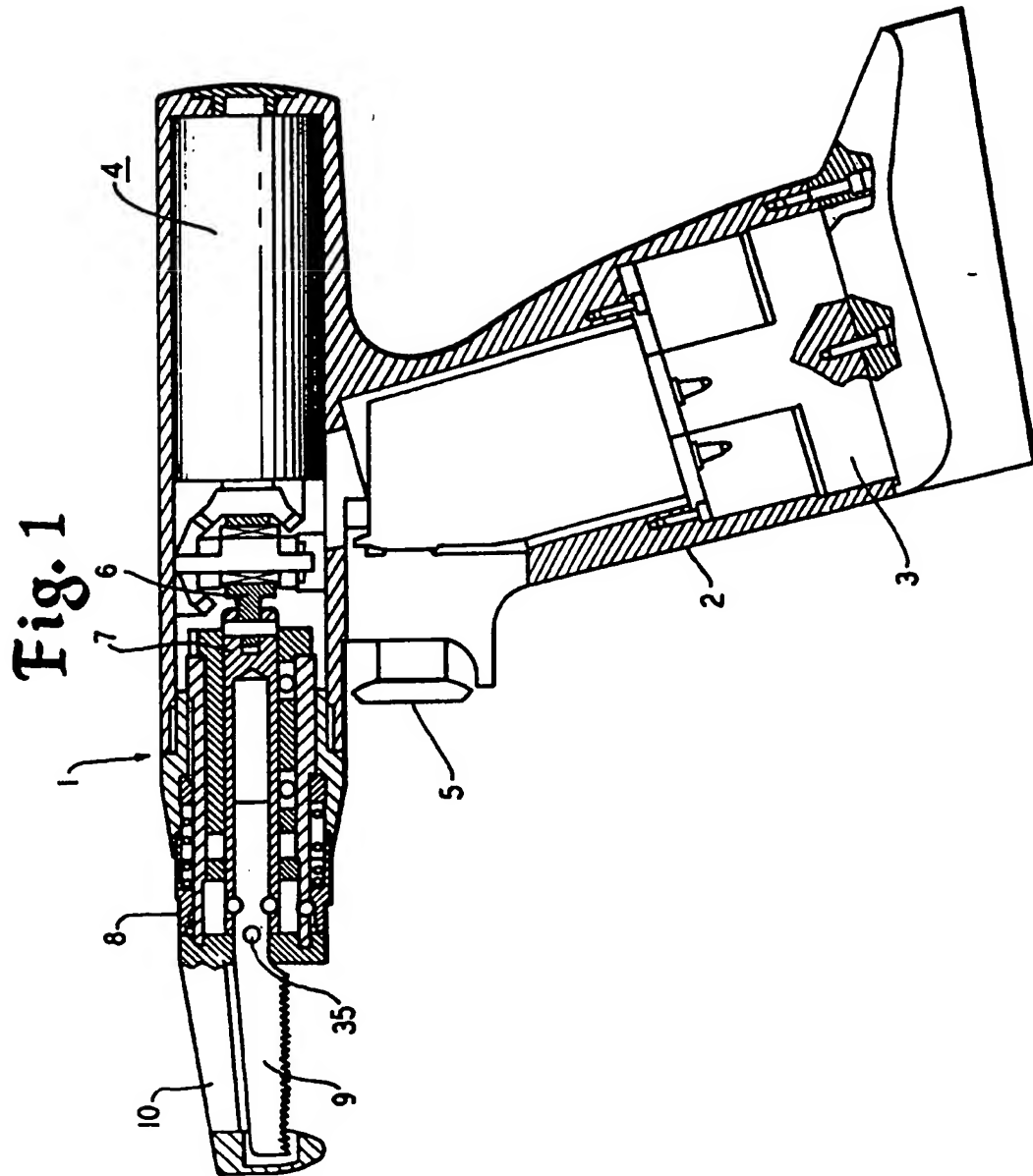


Fig. 2

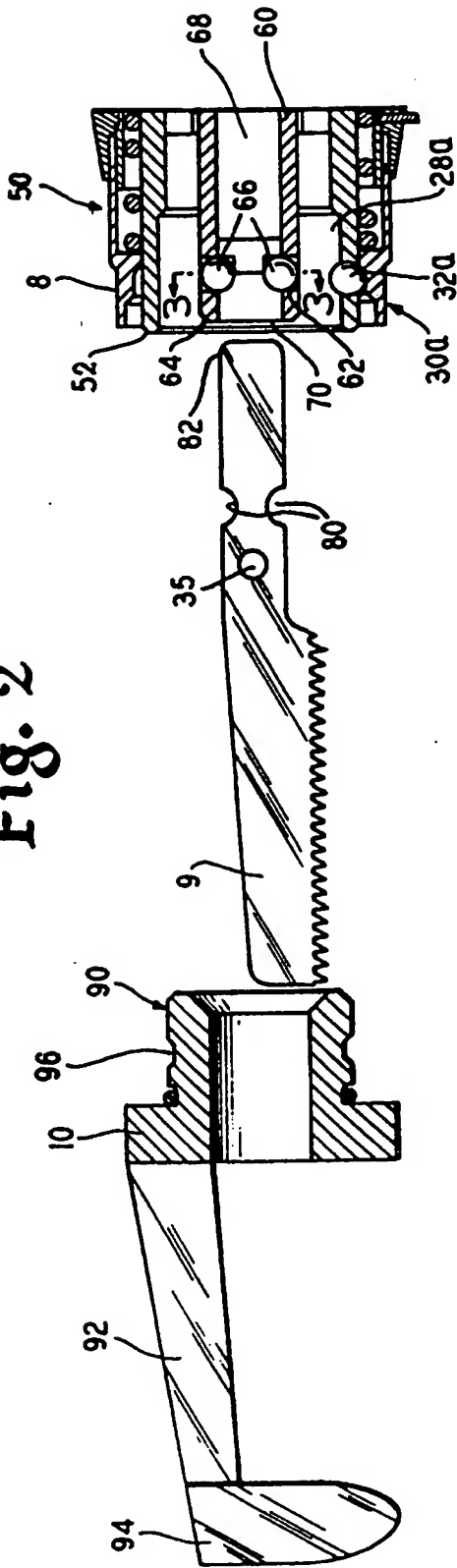
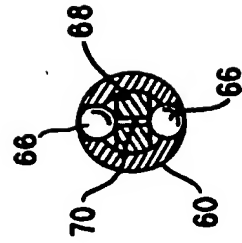
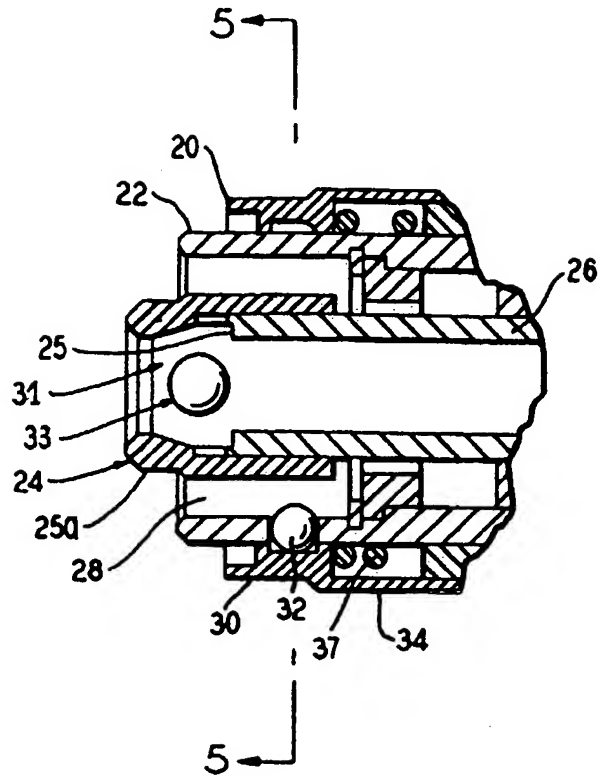


Fig. 3



**Fig 4**

PRIOR ART



**Fig. 5**

PRIOR ART

